

# UNDERSTANDING “SHAKEN BABY SYNDROME”

## and other forms of Abusive Head Trauma

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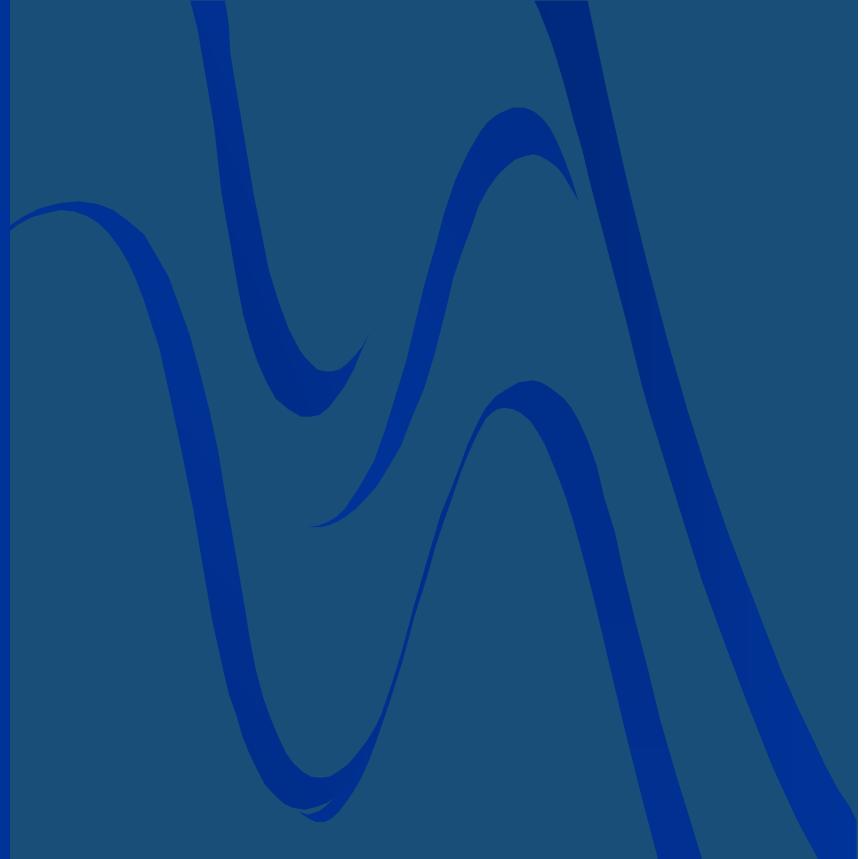


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# Overview of Abusive Head Trauma

- Definition of Shaken Baby Syndrome and other forms of Abusive Head Trauma
- Why are infants more susceptible?
- Who Are the Perpetrators and Why Do They Do It
- Clinical Presentation and Clinical Characteristics
- Differential Diagnosis of Abusive Head Trauma
- Controversies in “Shaken Baby Syndrome”

# **Definition of Abusive Head Trauma and Shaken Baby Syndrome**



# Abusive Head Trauma

- A diagnostic entity with many names:
  - Whiplash shaken-infant syndrome
  - Shaken baby syndrome
  - Shaken impact syndrome
  - Inflicted head trauma (or injury)
  - Inflicted childhood neurotrauma
- Head injuries associated with physical abuse.
  - The injury can include skin, subcutaneous tissues, skull, bleeding inside skull, injury to brain parenchyma (brain tissue)

# Shaken Baby Syndrome

- Clinical triad of:
  - Encephalopathy
  - Intracranial hemorrhages (SDH, SAH)
  - Intraocular hemorrhages (retinal, vitreous)
    - + / - other signs of trauma
- Brain injuries associated with a history of shaking by another or an absent history of any trauma or an inadequate history to explain the type and severity of the injuries

# Abusive Head Trauma Shaken Baby Syndrome Shaken-Impact Syndrome

- Child abuse is the most common cause of serious head injury in children <1 y.o.
- Most victims <3 y.o.
- Mechanisms- shaking + impact, or impact
- Impact associated with more fatalities

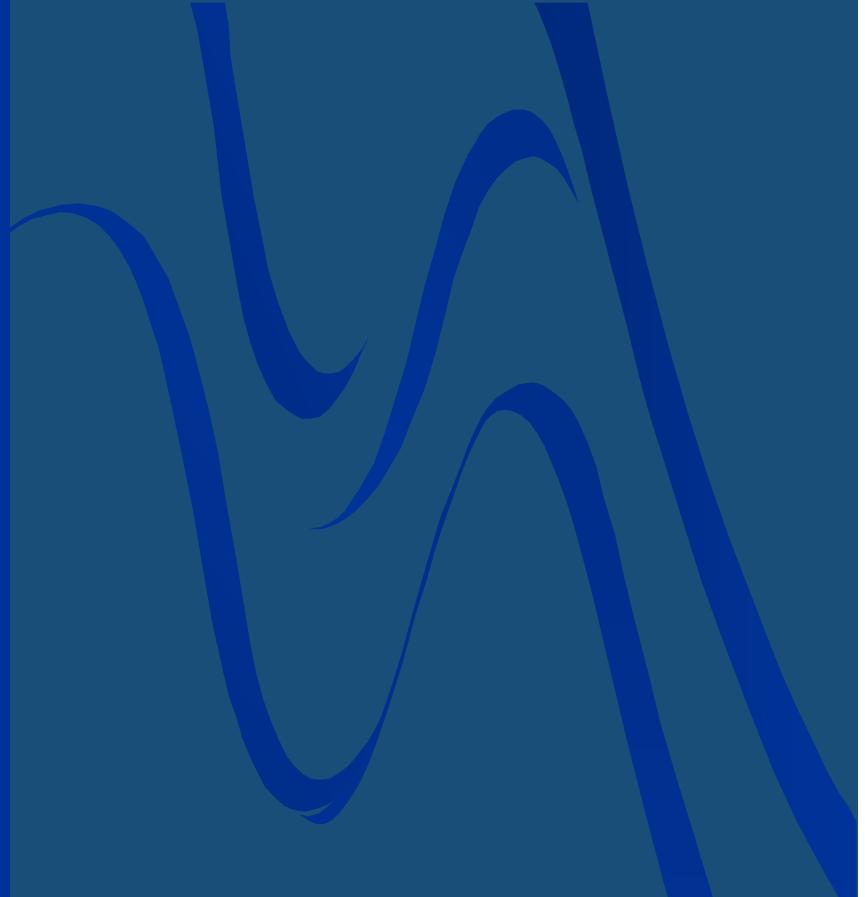
# Abusive Head Trauma

- Most common cause of mortality and morbidity in physical child abuse
- Brain injury – in 60% of inflicted injury deaths
  - 33%-56% of brain injuries in children < 1 year of age were inflicted.
- Estimates of annual AHT/SBS cases in US range from 600-1 500

# Abusive Head Trauma: demographics

- Male infants are at increased risk (54-64%)
- Young mothers, poor prenatal care, low income
- Race/ethnicity not a predictor
- Children < 12 m.o. were at higher risk than children > 12 m.o. (mean age 2.3 to 8.7 months)
- North Carolina      31/100,000 per year <12 m.o.  
■ North Carolina      17/100,000 per year >12 m.o.  
■ Scotland              25/100,000 per year <12 m.o.  
■ Scotland              0/100,000 per year >12 m.o.  
■ S. Wales/W England 10/100,000 per year <12 m.o.  
■ Estonia                29/100,000 per year <12 m.o.

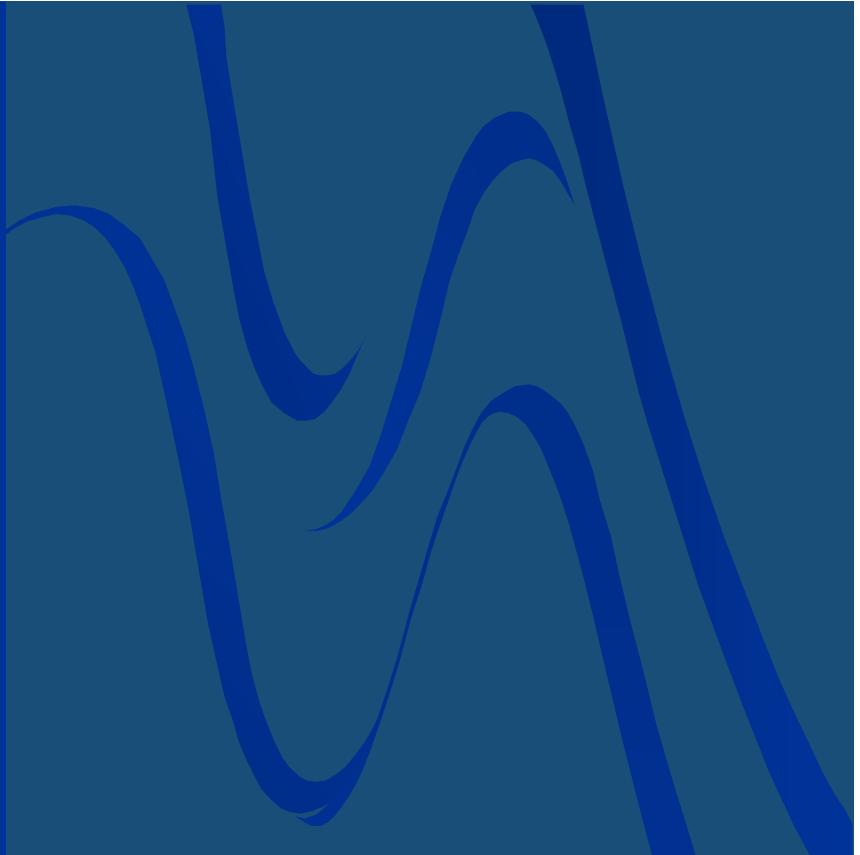
# Why Are Infants More Susceptible



# Abusive Head Trauma – Why are infants more susceptible?

- Small body size
- Weak neck muscles/poor head control
- Larger subarachnoid space
  - Larger fluid space surrounding brain
  - Relatively soft and gelatinous brain
  - Higher water content
    - Less myelination
    - Large ratio of head to body size

# Who Are the Perpetrators and Why Do They Do It



# Abusive Head Trauma – Who are the perpetrators and why do they do it?

## ■ “Risk factors”

males

younger age  
low education level  
impulsive, childish

drug use

depression

DV

dependent personality

## ■ Males predominate (60-70%)

- Father 33-37%
- Mother’s boyfriend 20-64%
- Female babysitters 17-30%
- Mother 6-13%

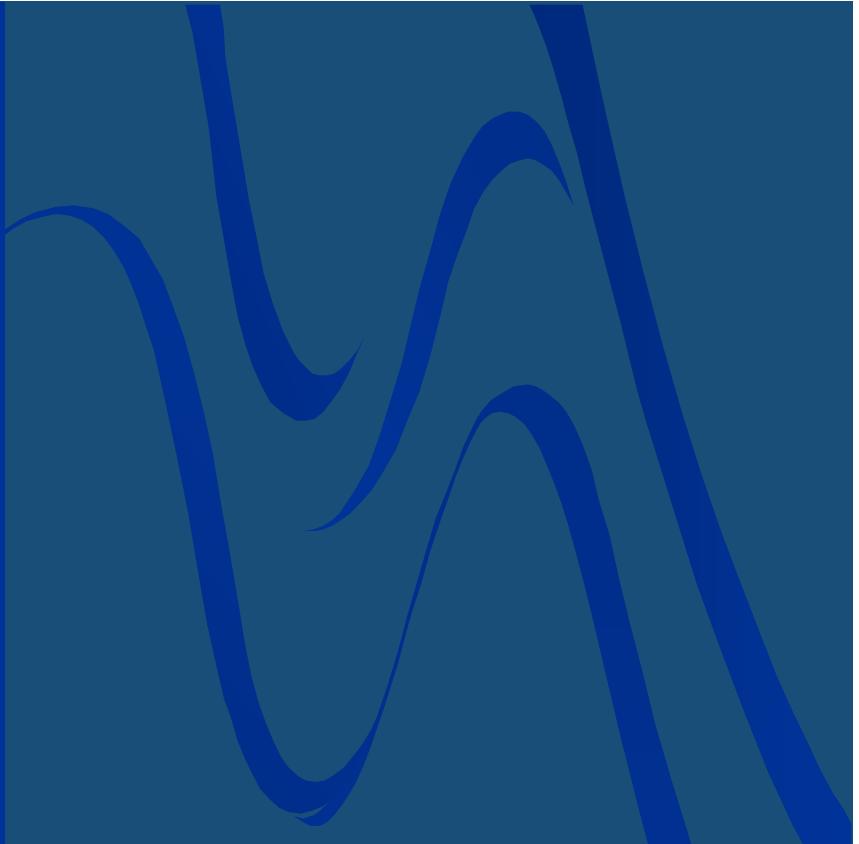
# Abusive Head Trauma – Who are the perpetrators and why do they do it?

- Why do they do it

## ■ CRYING!

- ‘Disobedience’
- Feeding difficulty
- Physiologic misadventures

# Abusive Head Trauma - Clinical Presentation and Clinical Characteristics



# Common presenting signs and symptoms

may be subtle or dramatic, related to severity

- poor feeding
- vomiting
- lethargy
- irritability
- respiratory symptoms, apnea
- impaired consciousness
- seizures
- Obvious physical injury
- respiratory distress or apnea
- death

# Explanations provided for injuries

- often vague, changes with time
- no predisposing event in up to 1/2
- minor fall in about 1/3
- minor fall plus “shaking” to revive child
- respiratory arrest, apnea or seizure at home
- struck by caretaker
- shaking only

## Missed cases of abusive head trauma

- Jenny et al 1999 evaluated 173 children <3 y.o.
  - 54 (31.2%) seen by doctor previously and misdiagnosed
  - 27% Of missed children were reinjured
  - 4 children died

# Missed cases of abusive head trauma

- Missed diagnoses included:
  - “accidental” trauma
  - Gastroenteritis
  - Reflux
  - Apnea / ALTE
  - Seizure disorder
  - Sepsis
  - Otitis media

# Characteristics of missed cases of abusive head trauma

- Young infants
- Caucasian children
- Children from 2-parent households
- Children without seizures or respiratory compromise

# Intracranial injury can be clinically silent

- Gruskin and Schutzman 1999 – 101 cases TBI - 75% of children younger than 2 y.o. had non-focal exams and normal level of consciousness – 19 cases “occult”
- Rubin et al 2003 - in a group of 51 children <2 y.o with “high risk” inflicted injuries but no Hx of neuro symptoms and normal neuro exams 19 (37.3%) had occult head injury – all but one <12 mo.

# Intracranial injury can be clinically silent

- Laskey et al 2004 evaluated 51 children <48 mos. suspected abuse but no clinical HX or signs of neuro injury
  - 38 (75%) had neuroimaging and 11/38 (29%) had intracranial injury
  - If child <12 mos. 31% +, >12 mos. 25% +
  - Only 1/35 screened had RH
- Of those with + neuroimaging
  - 6/11 had + skeletal survey
  - 1/11 had + skeletal survey and + RH

# Comparison of serious inflicted and non-inflicted head trauma

- Keenan et al 2004 evaluated 152 children <24 mos.
- Reasons for seeking care

	inflicted (80)	non-inflicted (29)
■ Apnea	17.5%	0%
■ Respiratory distress	12%	0%
■ Found lifeless	14%	0%
■ Seizure	12.5%	0%
■ Facial/ head swelling	0%	24%
■ Parents concerned	0%	21%
■ Lethargy	10%	21%
■ Unresponsive	9%	14%
■ Vomiting	4%	14%

# Comparison of serious inflicted and non-inflicted head trauma

- Keenan et al 2004 evaluated 152 children <24 mos.
  - Mechanism initially reported
- | Mechanism            | Inflicted (80) | Non-inflicted (72) |
|----------------------|----------------|--------------------|
| No explanation       | 64%            | 0%                 |
| Shaken / hit         | 2.5%           | 0%                 |
| Shaken to revive     | 4%             | 0%                 |
| Fall                 | 15%            | 24%                |
| Dropped              | 7.5%           | 11%                |
| Other                | 6%             | 6%                 |
| Car / pedestrian-car | 0%             | 53%                |

# Comparison of serious inflicted and non-inflicted head trauma

- Keenan et al 2004 evaluated 152 children <24 mos.

- Types of injuries

	inflicted (80)	non-inflicted (72)
■ Retinal hemorrhages	76%	8%
■ Rib fractures	28%	6%
■ Long bone fractures	19%	7%
■ Skull fracture	18%	59%
■ Metaphyseal fracture	18%	3%
■ Subdural hematoma	94%	61%
■ Anoxic injury	19%	11%
■ Parenchymal bleed	7%	15%
■ Epidural bleed	1%	18%

# Common patterns of injury

- Intracranial injury
  - Injuries surrounding brain
  - Brain injury
- Retinal hemorrhages
- Fractures
  - Skull
  - Ribs
  - Long bones
- Bruises
  - Head or facial
  - Arms or chest

# Patterns of injury – associated intracranial injuries

- injuries external to brain
  - epidural hematomas (uncommon)
  - subdural hematomas (most common)
  - subarachnoid hematomas (common)
- injuries to cerebral hemispheres, brain parenchyma
  - cerebral contusions / shearing injury
  - cerebral edema
  - cerebral infarction

# Patterns of injury – retinal hemorrhages

- retinal hemorrhages important but not always present and may be seen in other conditions.
- RHs can be seen in newborns but resolve within 3-6 weeks
- RHs in abuse are frequently numerous, intraretinal, involve all layers of the retina, and extend to the periphery of the retina – retinal folds or detachment and vitreous hemorrhages may occur

# Patterns of injury – associated fractures

Fractures are present in many cases

- Rib fractures
  - Caused by gripping associated with shaking
  - Often posterior, usually not associated with bruises
- Skull fractures
  - Evidence of impact
- Long bone fractures
  - Metaphyseal fractures due to “whiplash” mechanism

# Patterns of injury – associated bruising

Bruises are absent in most cases

- Facial and scalp bruises
  - Evidence of impact
  - Scalp injuries sometimes not seen on surface
- Subgaleal hematomas
  - Evidence of impact
- Arm and chest bruises
  - Caused by gripping associated with shaking

# Evaluation of injuries

## ■ Brain injuries

### CT scan

high specificity and high sensitivity for acute injury  
best study to evaluate acute hemorrhage

### MRI scan

high specificity and high sensitivity for subacute and chronic injury  
best study to fully assess intracranial injury  
may miss acute subdural or subarachnoid hemorrhages

# Evaluation of injuries

- **retinal hemorrhages**  
often are visible with direct ophthalmoscope, but more easily documented using an indirect ophthalmoscope after dilating the pupils
- **bone injuries**  
skeletal survey – best initial study  
bone scan
- **cutaneous injuries**  
general physical examination  
coagulation studies – CBC, PT, PTT, platelet count
- **visceral injuries**  
liver enzymes, pancreatic enzymes, U/A

# Who do you test for inflicted TBI?

- When infant (toddler) has some other sign of suspected abuse.

- When infant has neurological symptoms?  
What symptoms?

# Differential Diagnosis of Abusive Head Trauma

# Differential Diagnosis of Abusive Head Trauma

- Other explanations for brain injury
- Other explanations for retinal hemorrhages
- Other explanations for associated injuries (fractures, bruises)
- Other explanations for all the above combined

# Differential Diagnosis of Abusive Head Trauma

## ■ Other Explanations for Traumatic Brain Injury

Unintentional head trauma (falls, toppled TVs)

Strangulation, suffocation, asphyxia, SIDS

Coagulation disorders

Benign extra-axial fluid collection

Glutaric aciduria type 1

Osteogenesis imperfecta

# Differential Diagnosis of Abusive Head Trauma

## ■ Other Explanations for Traumatic Brain Injury

Prenatal or perinatal trauma

Arteriovenous malformations

Cerebral sinovenous thrombosis

Brain tumors

Infections (herpes)

Folk medicine (*caida de mollera*)

# Differential Diagnosis of Abusive Head Trauma

## ■ Other Explanations for Retinal Hemorrhages

Unintentional injury (Falls, MVA)

Coagulation disorders

Vaginal delivery

Glutaric aciduria type 1

Increased intracranial pressure

# Differential Diagnosis of Abusive Head Trauma

- Other Explanations for Retinal Hemorrhages
  - Hypotension/hypertension

Anemia

Chest compression/CPR

Convulsions

Meningitis

Carbon monoxide poisoning

# Differential Diagnosis of Abusive Head Trauma

## ■ Other Explanations for Associated Injuries

### Fractures

- unintentional injury
- perinatal trauma
- infectious, genetic or metabolic bone disease

### Bruises

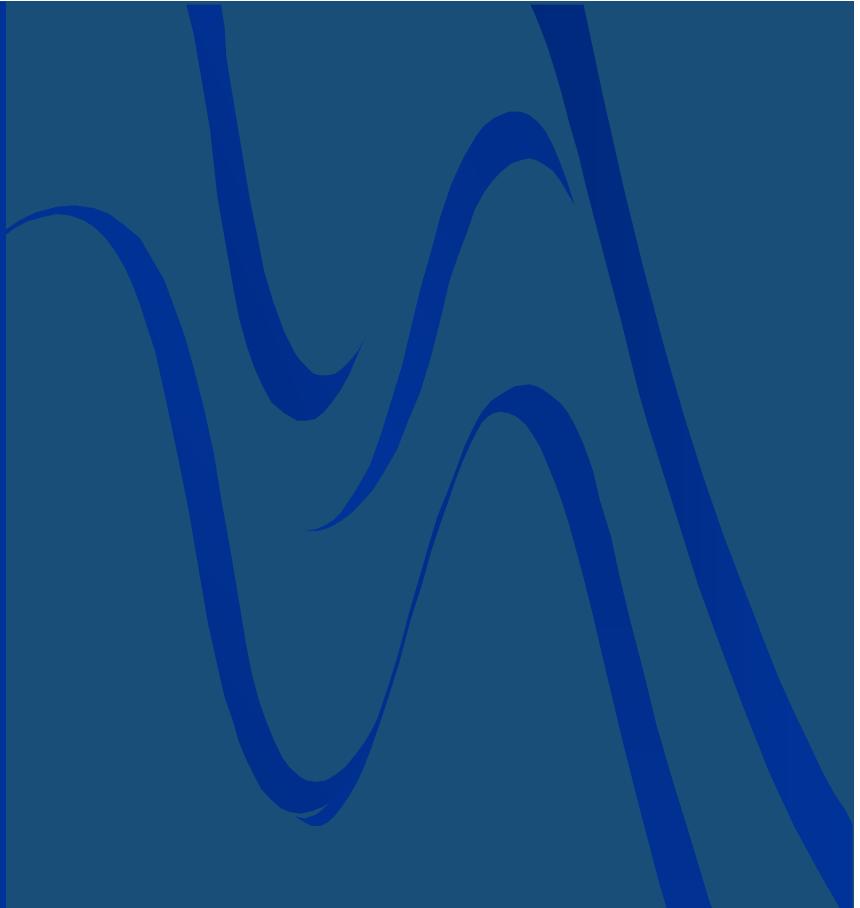
- unintentional injury
- coagulation disorders

# Differential Diagnosis of Abusive Head Trauma

- Other Explanations for All the Above Combined
  - Unintentional injury (SDH, RH, F, B)
  - Coagulation disorder (SDH, RH, B)
  - Perinatal trauma (SDH, RH, F, B)
  - Bone disease (F only except for OI having SDH, F)

In reality, nothing explains the combination of the SDH, numerous RH in all layers to ora serrata, classical rib or metaphyseal fractures, and certain bruise patterns in babies

# Abusive Head Trauma - Prognosis / Consequences



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# Prognosis / consequences

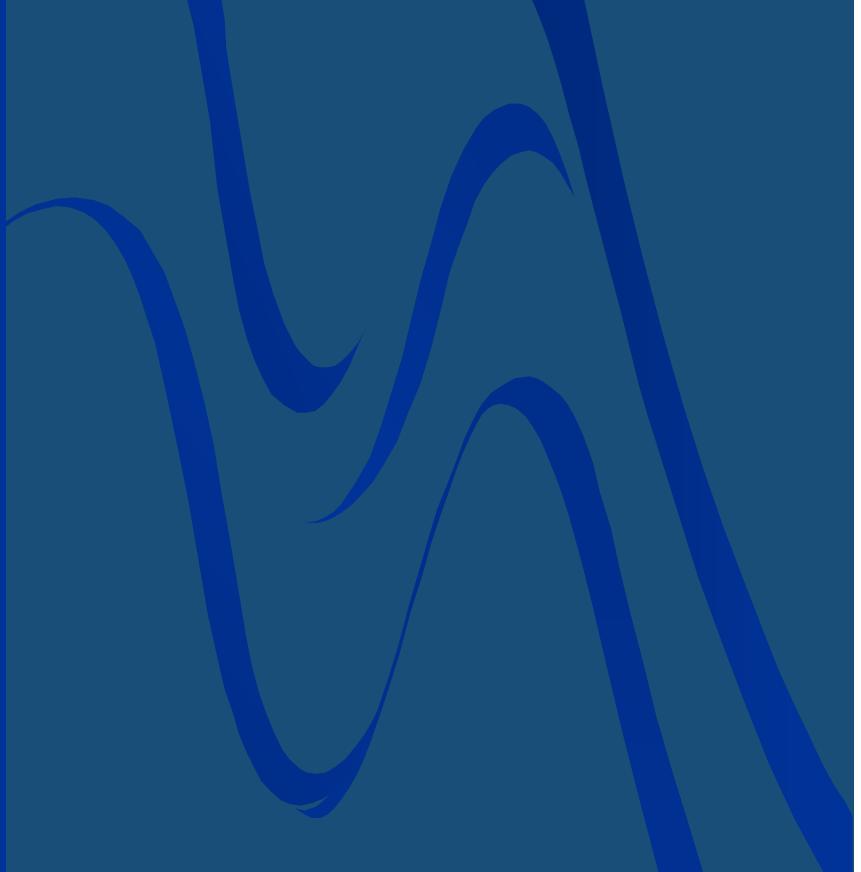
- High risk for permanent brain injury and death
- Mortality rate approximately 20%
- About half have obvious disability, and 25-35% “appear normal” at hospital discharge
- Long-term morbidity high amongst survivors – up to 90% affected
  - About 1/2 of survivors have severe disability
  - About 1/4 of survivors who appear normal at discharge will develop severe developmental problems

# Prognosis / consequences

high risk for permanent brain injury and death but outcome for infants not brought to medical care unknown

- seizure disorder
- behavior disorders
- learning disorders
- mental retardation
- cerebral palsy
- blindness
- vegetative states
- death

# Controversies in SBS



# Controversies in SBS

- Mixed density subdural hematomas
  - Multiple episodes of trauma
  - Mixing of blood with CSF
- Shaking versus shaking/impact
  - Many victims have physical findings and or confessed histories of shaking plus impact
  - No experimental model shown sufficient force to produce injury
  - No experimental model equal to a human infant

# Controversies in SBS

- Are certain infants more susceptible to bleeding
  - Infants with abnormal brain development
  - Infants with prior head injury
  - Infants with enlarged subarachnoid spaces
- Serious head injuries from short falls
  - Serious head injuries are rare from short falls
  - Epidural hematomas are the exception

# Short Fall Mortality

- Study by Plunkett, 2001 based on U.S. CPSC data for playground falls over 11 yr. period
  - 18 deaths in 75,000 cases reviewed
  - estimated heights 2 – 10 feet
  - Ages 1 year - 13 years – no infants, 5 cases 12-24 m.o.
  - 6 cases un witnessed including 4 / 5 cases 12-24 m.o.
  - 2 had at risk medical conditions
  - None had formal ophthalmologic examinations

# Short Fall Mortality Statistical Analysis

- Deaths due to short falls do occur but are extremely rare.
  - 0.14 - 0.22 deaths/year / 100,000 children aged 0-4 years
  - 0.056 - 0.44 deaths/1,000,000 short falls in children aged 0-4 years
- Special subtypes of short falls may have a higher mortality rate, but it is still very low.

# Controversies in SBS

- Neck Injuries
  - Neck injuries should be seen in whiplash
  - Neck injuries are often not found
- “Lucid Interval” and timing of injuries
  - Symptoms may develop after a “lucid interval” not immediately (“walk and talk then die”)
  - Lucid intervals rare in witnessed nonintentional injury and usually accompany epidural hematomas

# Admission of inflicted head injury

- Starling et al 2004 reported 171 cases,  
81 with admissions by abuser
- 69/81 cases can determine mechanism
  - Impact only 20 17 SDH 14 RH
  - Shaking only 32 29 SDH 27 RH
  - Both 17 17 SDH 16 RH
- Onset of symptoms known 57 / 81
  - Immediate 52 (91%)
  - Within 24 hours 5

# Timing of the injury

- except for cases of epidural hematomas, children who die from accidental head trauma, have an immediate decrease in LOC
- there is no scientific evidence to support a prolonged interval between inflicted head injury and sudden deterioration
- timing in minor head trauma more problematic but physical and X-ray findings may help
- although rare episodes of rapid clinical deterioration following a repeated sports impact (second impact syndrome), there is little evidence that repeated trivial falls produce findings similar to inflicted head injury

# Conclusions

- Abusive head trauma is defined as head injuries associated with physical abuse
  - The injury can include skin, subcutaneous tissues, skull, bleeding inside skull, injury to brain parenchyma (brain tissue), and may be associated with fractures or other injuries
- The combined injury pattern and clinical symptoms is critical to establishing the diagnosis of abusive head injury
  - Arguments based on individual injuries and individual symptoms are not valid

# Conclusions

- Present biomechanical models derived from adult primates are inadequate to describe the response of the infant brain to repeated shaking movements
  - Arguments based on those models are invalid
- Exact timing of injuries on medical grounds is difficult
  - Clinical information suggests that onset is immediate in infants with most severe injuries
- Clinical observations and confessions suggest that shaking, with or without impact is an extremely common mechanism for these injuries